Variability of motor moment during golf swing: study of a female professional player

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M. Bourgain[a,b], T. Provot[a,b], C. Sauret[b,c], L. Valdes-Tamayo[b], O. Rouillon[d], P. Thoreux[b,e] and P. Rouch[b]

[a]EPF – Graduate School of Engineering, Sceaux, France; [b]Arts et Métiers Institute of Technology, Institut de Biomécanique Humaine Georges Charpak, IBHGC, Paris, France; [c]Institution nationale des Invalides (INI)/CERAH, Créteil, France; [d]Fédération Française de Golf, Levallois Perret, France; [e]Université Sorbonne Paris Nord, Bobigny, France

1. Introduction

Golf swing performance has been widely studied. Performance parameters based on various mechanical concepts were developed such as X-factor (Kwon et al. 2013), or ground reaction forces (McNitt-Gray et al. 2013), for instance. More recently, parameters based on the capacity to generate motor moments were introduced (Bourgain et al. 2017) to better describe performance.

However, this parameter is a composition of the ground reaction forces, body position and club positions. So, its control requires to control each element and to reduce their variabilities.

Thus the aim of this publication was to estimate the intra-subject variability of the motor moment and its contributors during a golf swing.

2. Methods

2.1. Experimentations

One female professional golfer participated to this study, which had received ethical agreement from an external ethical committee (2015-A01760-49, Ile de France X). After giving her written consent, she performed her personal warm-up routine, and then performed 10 swings with her own driver, in a motion analysis laboratory. It was equipped with a 12-cameras optoelectronic motion capture system (Vicon system, Oxford metrics, UK; 200 Hz), coupled with 2 force plateforms (OR6, AMTI; 1200 Hz), one under each foot, allowing the measurement of ground reaction forces under each foot during the swing. The global reference frame was defined with x-axis medio-lateral, pointing toward the right, y-axis antero-posterior pointing forward and z-axis vertical pointing upward. The swing performance was assessed with a dedicated ball launch radar (TrackMan 3, Trackman, USA) and defined as the clubhead speed at impact.

2.2. Processing

The instants of the downswing were visually estimated (top of backswing and ball impact). The beginning was defined when the clubhead changed its direction when behind the golfer, and the end (corresponding to impact) when the club was at the same position than at the address.

The segments position amont time was estimated with a multibody kinematic approach performed on OpenSim (Delp et al. 2007), with the model described by Bourgain et al. (2018). The global centre of mass (CoM) was calculated by the barycentre of all the body segments centre of mass, among time.

The clubhead marker positions were used to compute the swing plane. It was computed as the plane minimizing the squarre distance with all the positions from mid-downswing to impact, according to Morrison et al. (2018).

Motor moment was defined as the sum of the moments produced by each component of the ground reaction forces (GRF) at the CoM, according to the vector perpendicular to the swing plane.

2.3. Variabilities assessment

For all parameters, the variability was assessed over the 10 swings, by computing its standard deviation (SD) and coefficient of variation (CV). The instant T_{max} was defined when the motor moment reached its maximum and ΔT_{max} corresponded to the duration between T_{max} and impact. GRF variabilities were assessed at the instant T_{max}.

3. Results and discussion

The performance varied from $44.7.s^{-1}$ to $46.3\,m.s^{-1}$, with a mean value of $45.2\,m.s^{-1}$ and a SD of $0.4\,m.s^{-1}$ corresponding to 1% of variation. The duration of the downswing was on average of 0.28 s with a SD of 0.01 s, which is in accordance with the study of Egret et al.

Table 1. mean values, standard deviation and coefficient of variation of motor moment and GRF at the instant T_{max}.

Values at T_{max}	Mean	SD	CV[%]
Mmot [N.m]	58.24	8.56	14.69
Trailed FX [N]	−35.11	3.32	9.45
Trailed FY [N]	−9.39	4.04	42.99
Trailed FZ [N]	296.04	10.09	3.41
Lead FX [N]	48.85	3.77	7.72
Lead FY [N]	14.74	4.21	28.54
Lead FZ [N]	281.04	8.93	3.18

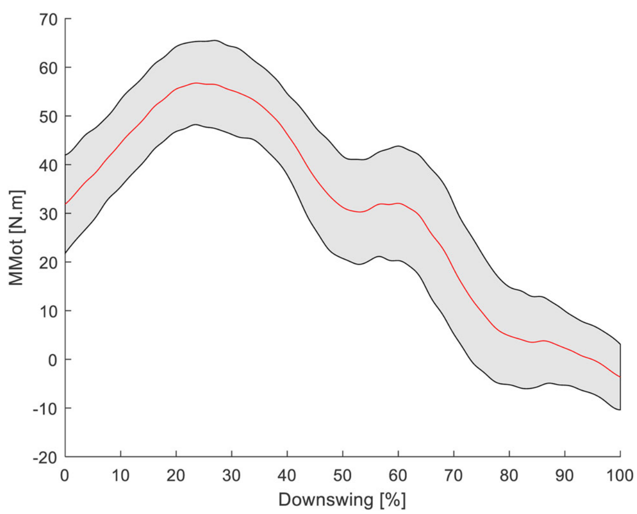

Figure 1. Evolution of the motor moment during the downswing, mean value in red, corridor of +/-1 SD in grey.

(2006). The time to impact, ΔT_{max}, was of 0.21 s and had a variation of about 7% with a SD of 0.01 s, however, this value is close to the limit of sensitivity of the method as the acquisition frequency of the kinematics data was 200 Hz.

The mean values and variations at T_{max}, of the motor moment and the GRF were written in the Table 1. Vertical ground reactions forces had a lower CV than horizontal ones, but had a higher SD. Horizontal ground reaction force had a higher variability, however their absolute were lower. The motor moment had a higher CV than vertical ground reaction forces, thus, horizontal ground reaction forces variation may induce a part of its variability.

The evolution of the mean value of the motor moment and its variation among the downswing were reported in the Figure 1.

4. Conclusions

The duration of the downswing was the more reproducible parameter, with a variation close to the limit of measurement. As the reproducibility is needed to perform in golf, the reduction of variability is essential for professional golf players. This professional golfer had a range of clubhead speed of 1.59 m.s^{-1} and this variability may be induced by a variation of motor moment. Thus the control of all the element to produce the motor moment such as GRF seemed essential. However, this study only focus on GRF but CoM position and plane inclination variations should also be investigated.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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maxime.bourgain@ensam.eu